REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 1997	

4. TITLE AND SUBTITLE

Modeling of Arterial Baroceptor Feedback in a Hydromec Cardiovascular Pulse Duplicator System

5. FUNDING NUMBERS

PE – 61102F
PR – 2301
TA – AC
WU – 71

6. AUTHOR(S)

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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8. PERFORMING ORGANIZATION REPORT NUMBER

AL/AO-TM-1997-0001

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

We have developed a hydro-mechanical cardiovascular pulse duplicator system (CPDS) for modeling the systemic arterial system. The CPDS has the ability to reproduce physiologically equivalent aortic pressures and flows and has been used to test and evaluate electrical analog arterial models of the systemic circulation. Feedback from a flow probe from measuring flow through a simulated aorta has been developed for regulating cardiac output by controlling heart rate and/or stroke volume. The output from a pressure sensor adjacent to the flow probe provides the opportunity to regulate heart rate using pressure feedback. The primary objective of the proposed research was to test the hypothesis that a physiologically equivalent arterial-cardiac baroreflex feedback mechanism can be accurately modeled by integrating a pressure sensor into the existing CPDS. A secondary objective was to cross-validate the mechanical feedback model by comparing heart rate responses during tilt tests with those of existing physiologic experimental data. Because of significant cracks and leaks in various plexiglas parts of the original Ormec CPDS, a number of parts had to be refabricated. All of the parts subjected to the most stress were refabricated from aluminum and anodized for protection against corrosion. Aluminized parts included both walls of the atrium and inlet hose connection, and all inlet and outlet hose connections to the Systemic Reservoir with their supporting parts. All other parts which included the walls surrounding the mitral valve test section required fabrication from plexiglas in order to provide a clear view of the valve in the test section. All hardware fabrication has been and have been completed completed by the fabrication shop at Brooks AFB.

14. SUBJECT TERMS

Modeling; cardiovascular; blood pressure; blood flow; cardiac output; heart rate;

15. NUMBER OF PAGES

4

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

FY97 Entrepreneurial Research Final Report

Modeling of Arterial Baroreceptor Feedback in a Hydromec Cardiovascular Pulse Duplicator System - #2301AC71

Principal Investigator: Victor A. Convertino, Ph.D.

OBJECTIVE:

We have developed a hydro-mechanical cardiovascular pulse duplicator system (CPDS) for modeling the systemic arterial system. The CPDS has the ability to reproduce physiologically equivalent aortic pressures and flows and has been used to test and evaluate electrical analog arterial models of the systemic circulation (Koenig et al. in draft). Further, feedback from a flow probe from measuring flow through a simulated aorta has been developed for regulating cardiac output by controlling heart rate and/or stroke volume (Schaub et. Al., Physic. Educ., in review). The output from a pressure sensor adjacent to the flow probe provides the opportunity to regulate heart rate using pressure feedback. The primary objective of the proposed research is to test the hypothesis that a physiologically equivalent arterial-cardiac baroreflex feedback mechanism can be accurately modeled by integrating a pressure sensor into the existing CPDS. A secondary objective is to cross-validate the mechanical feedback model by comparing heart rate responses during tilt tests with those of existing physiologic experimental data.

APPROACH:

Accomplishing our proposed objectives required experimental preparation, data acquisition, data reduction and analysis, and publication of findings. First, the current CPDS required refurbishment. Second, the "normal" physiological response of arterial-cardiac barorecptors was to be determined from existing literature and experimental data. Third, the CPDS controller hardware was to be modified to include external input ports for the output of the pressure sensor. Fourth, the CPDS software control logrithms was to be developed for regulating pressure by altering the stroke rate (heart rate) of the pulsatile pump using the physiologically equivalent response characteristics determined in step two. Fifth, the pressure feedback feature was to be tested and evaluated by adjusting the peripheral resistance and cardiac output of the model in a randomized experimental design.

PROGRESS:

On 1 Jan 97, funding was approved, but at a level ($20,935) which was less than half of the $43,189 originally proposed (see attachment #1). We reviewed the proposed milestones to assess the impact of the reduced funding and informed the office of the Armstrong Laboratory Chief Scientist on 31 Jan 97 that only two of the original seven milestones could be successfully accomplished with the current funding (see attachment # 2). On 9 Apr 97, we were informed by the AO Chief Scientist that there was a recision of our ER funds by $10,000 (see attachment #3). The impact of this recision was an elimination of manpower funding to complete the project and the remaining funding was used to procure the required hardware for the project.

Because of significant cracks and leaks in various plexiglas parts of the original Ormec Cardiovascular Simulator Pulse Duplicator, a number of parts had to be refabricated. All of the parts subjected to the most stress were refabricated from aluminum and anodized for protection against corrosion. Aluminized parts included both walls of the atrium and inlet hose connection, and all inlet and outlet hose connections to the Systemic Reservoir with their supporting parts. All other parts which included the walls surrounding the mitral valve test section required fabrication from plexiglas in order to provide a clear view of the valve in the test section. All hardware fabrication has been and have been completed completed by the fabrication shop at Brooks AFB.

ATTACHMENT 1

Microsoft Mail v3.0 (MAPI 1.0 Transport) IPM.Microsoft Mail.Note
From: Mathias, James
To: Convertino, Victor
Osswald, Sandra
Block, Michael
Cc: Goral, Angela W
Subject: FY97 Entrepreneurial Research (ER) Funds
Date: 1997-01-15 08:59

Forwarded for your information. This message was the only "official" notification we received to date on the ER approved proposals. I would appreciate your input as to how each of you would like your funds distributed, especially as to base and medical supply loads. (I have already received Maj. Osswald's). Their goal is to have us obligate all funds as soon as possible. Headquarters is already asking us for projected earnings and expenditures as of 31 Mar 97 (end of quarter).

Should you have any questions concerning our FY97 ER funding, please do not hesitate to contact me at extension 4-4105 or by email.

Thank you in advance for your support and input.

Jim Mathias
AL/AOPR
Bldg. 125, Room 345
Phone 4-4105

Subject: FY97 Entrepreneurial Research (ER) Funds
Author: Maria Christensen at al-125
Date: 1/10/97 3:59 PM

1. AL/CA Memo, dated 13 Nov 96, subject: FY97 Entrepreneurial Research (ER) Program, listed the proposals that had been approved for funding. AL/AO had the following approved:

Effect of Volemic State & Fluid Distribution on Mitral Valve Movement (Dr Osswald) - $23,557 (CC 736263)

Effect of Sunlight on Plastic CR-39 Sun Lens Neutral Density (continuation of FY96 effort) (Maj Block) -- $5,000 (CC 736262)

Modeling of Arterial Baroreceptor Feedback in a Hydromec Cardiovascular Pulse Duplicator System (Dr Convertino) -- $20,935 (CC 736264)

Total funding for AO = $49,492.

2. Funds are being loaded by Gloria Durham, AL/FM, in cost centers referenced above.

3. Roxanne Constable, AL/CA, indicated that a copy of the AL/CA Memo referenced in Para 1 had been sent to Col McLean. He was to inform the scientists concerned.

Maria Christensen, Ext 4-5555

ATTACHMENT 2

DEPARTMENT OF THE AIR FORCE
ARMSTRONG LABORATORY (AFMC)
BROOKS AIR FORCE BASE, TEXAS

31 Jan 97

MEMORANDUM FOR AL\CA

FROM: AL/AOCY

SUBJECT: - Impact of Insufficient Funding for ER Proposal

We have recently been informed that our ER proposal "Modeling of Arterial Baroreceptor Feedback in a Hydro-Mechanical Cardiovascular Pulse Duplicator System" was approved and funded at $20,935.00. This funding level is less than half of the original request to accomplish this project ($43,189.00).

We have reviewed the proposed milestones to assess the impact of this reduced funding. Of the seven milestones projected, only two can be accomplished with the current funding: 1) refurbishment of hydro-mechanical components of the cardiovascular pulse duplicator system (CPDS); and 2) modification of the controller hardware to include pressure feedback only, without physiologically based control as was originally planned.

Upon completion of these two milestones, we will maintain the CPDS until the additional funding necessary to complete the project is received.

Victor A. Convertino

VICTOR A. CONVERTINO, GS-15
Chief, Physiology Research Branch

ATTACHMENT 3

From: Kent_M.Mclean@platinum.brooks.af.mil[SMTP:Kent_M.Mclean@platinum.brooks.af.mil]
Sent: Wednesday, April 09, 1997 10:55 AM
To: Constable, Roxanne
Cc: Mathias, James; Goral, Angela W; Marden, Harry; Convertino, Victor; Osswald, Sandra; Christensen, Maria
Subject: Recision of FY97 AFOSR Funds

AO will allocate the $13K recision as follows:

PI: Convertino
JON: 2301AC71 (Arterial Baroreceptor Model)
Source: ER
Amount: $10K
Impact: Elimination of manpower funding. Equipment for project will be procured in anticipation of future funding for manpower component. PROJECT ON HOLD.

PI: Osswald
JON: 2301AC72 (Volemic State/Mitral Valve Movement)
Source: ER
Amount: $3K
Impact: Reduced equipment procurement ($2K) and manpower funding ($1K). Equipment will be borrowed from other (related) projects, slowing progress and reducing productivity of this project.

For any questions, I may be reached at ext. 4-4112. K. McLean